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Acoustic Interrogation in Safeguards



Non-Invasive Acoustic-Based Monitoring of Heavy Water

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12 Jul 2018

Heavy Water Production Monitoring: A Recent Challenge for the IAEA



Arak Heavy Water Production Facility
Girdler sulfide process + distillation



JCPOA-130 metric ton limit

Non-invasive acoustic-based monitoring of Hydrogen/Deuterium ratio

- Context: There is a need for real-time process monitoring and person-portable in-field tools for the determination of the hydrogen /deuterium ratio (H/D) in heavy water production facilities.
- Current methods for H/D determination require periodic sampling and analysis. This approach does not provide the opportunity for continuous monitoring and verification by the IAEA and is relatively expensive, error prone and inefficient.
- Acoustic methods provide the opportunity to measure H/D for near real time process monitoring, noninvasive (dry) in situ inventory verification measurements (kegs) and rapid, reliable onsite wet measurements.
- Acoustic methods leverage the fact that sound speed is sensitive to the deuterium content of heavy water and can be measured using well established theory and commercial components.

Project Goal

- Develop a new verification capability that is
 - Nondestructive
 - Nonintrusive
 - Easy to deploy
 - Reliable and accurate

Non-invasive acoustic-based monitoring of Hydrogen/Deuterium ratio

- We propose an approach that can lead to a precision and accuracy of better than $\pm 0.2\%$, volumetric.
- A quick literature search leads to precisions of $\pm 0.2\text{-}0.4\%$ using other methods, gravimetric, float bath, displacement, mass spectrometry, IR Spectroscopy, emission spectroscopy, nuclear magnetic resonance, cryoscopy, refractometry, etc.)
- All these require drawing of a sample, elaborate sample preparation, time consuming, depends on user interpretation.
- Our approach consists of a clamp-on type device/sampling cell that can accurately measure D_2O concentration in real-time in real settings.

Noninvasive Measurements in SFAI Cell

Lab environment



Anton-Paar

Lab SFAI cell



Field



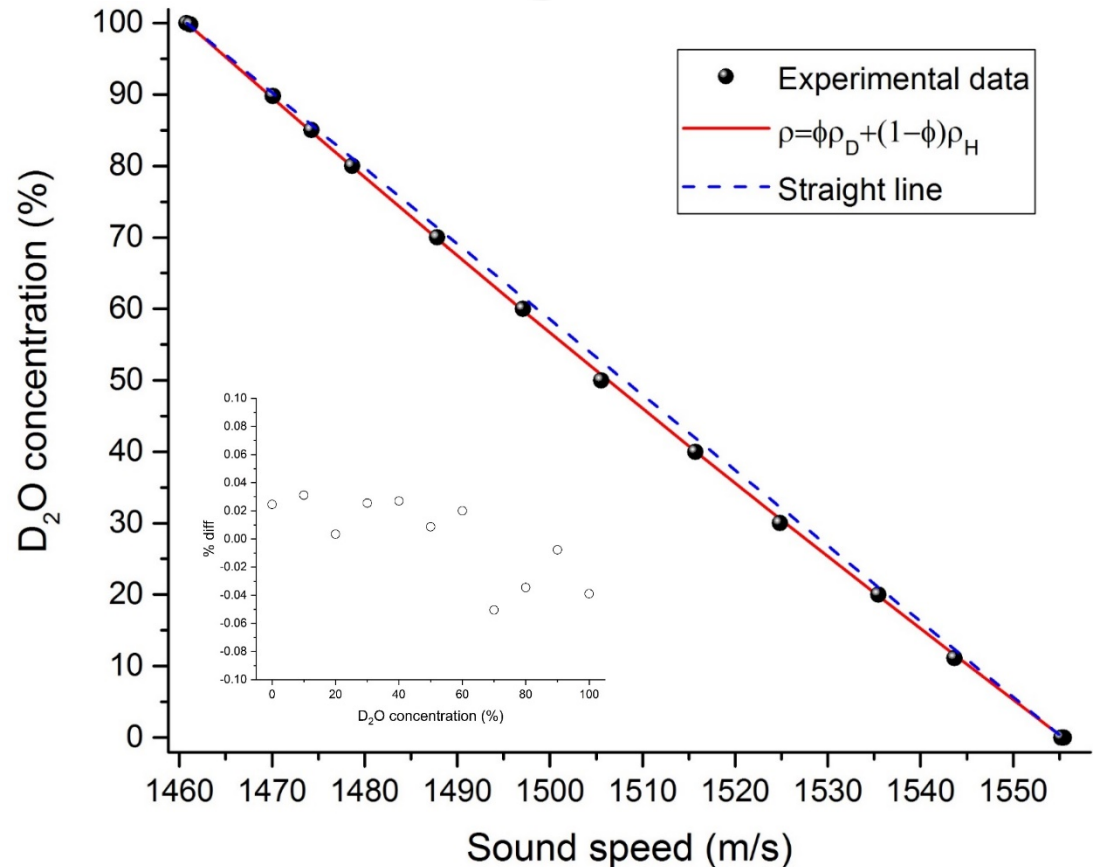
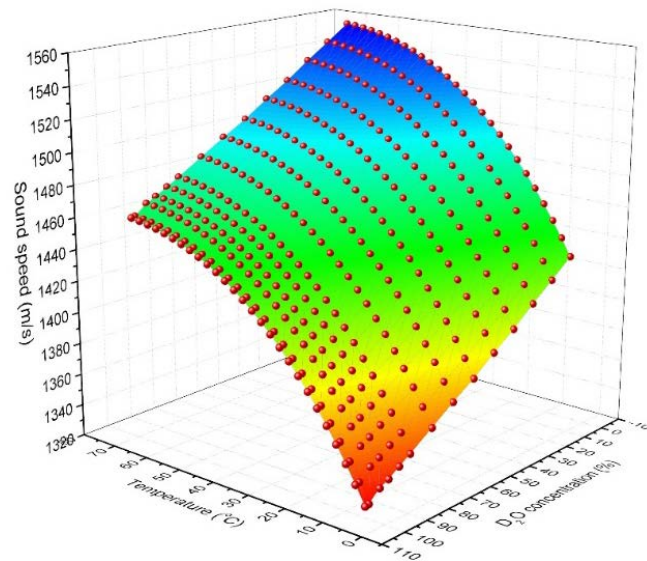
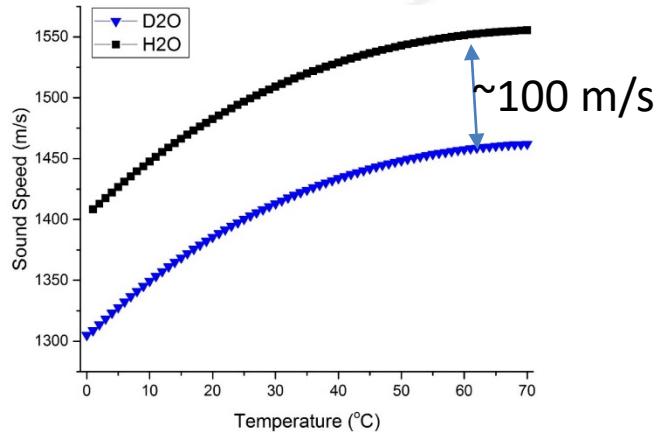
SFAI: Swept-Frequency Acoustic
Interferometry

- was developed 20+ years ago in our lab



Highest Precision Sound Speed Data Available: New Standard in H/D

→ high precision/accuracy for D₂O concentration, ~ 0.1%



*precisions of ± 0.2 - 0.4% using other methods, gravimetric, float bath, displacement, mass spectrometry, IR Spectroscopy, emission spectroscopy, nuclear magnetic resonance, cryoscopy, refractometry, etc.)

Slide 7

Timeline

- **Task 1 Portable on-site inspection tool development – CONOPS 1 (FY18-FY19)**

Deliverable 1: Portable tool functionality demonstrated in the laboratory (end of FY18).

- **Task 2 User-friendly software interface development (FY18-FY19)**

- **Task 3 Continuous unattended monitoring development – CONOPS 2 (FY19)**

Deliverable 2: Continuous unattended tool functionality demonstrated in the lab (end FY19).

- **Task 4 Field tests and technique refinement (FY20)**

Test/demonstrate developed system in an actual environment.

Deliverable 3: Demonstration of system in field functionality similar to the one observed in tests in the laboratory.

Status

- **Task 1** *on track – sampling cell functionality demonstrated; need temperature controller – working on clamp-on tool*
- **Task 2** *on track – working on data acquisition interface*
- **Task 3** *work will start in FY19*
- **Task 4** *work will start in FY20*



*Sampling cell
field testing prototype
available in 3-9 months

Summary

- Developed methodology for in-situ and onsite verification of D₂O inventory
- Simple, low cost, modest electronics, easy deployable

